Alleviating soil compaction can increase grassland productivity: a demonstration project

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Abstract

An estimated 70% of grassland soils in England and Wales exhibit signs of surface compaction. Soil compaction can result in reductions in grassland productivity and utilisation, impact on soil trafficability and health, and cause an increase in nitrous oxide emissions. Mechanical aeration of soils has been identified as a potential method of remedying soil structure in compacted soils. However, conflicting evidence exists as to the impact of these techniques on grassland productivity in compacted soils. Two commercial farms in the UK were used to demonstrate the effectiveness of sward-lifting and slit aeration on the dry matter yield and quality of grazing pastures. One site was located on a sandy loam soil and one on a clay loam soil. Average precipitation on the two farms ranged from 710 to 800 mm per annum. Both sites are located on improved, lowland grassland. Aeration was undertaken in the autumn and grass growth and utilisation were measured in the following season. Across both farms, grass yield response to surface aeration varied from -18 to +11% when compared with a non-aerated area. Negative results obtained at one site probably reflect inappropriate soil conditions at the time of aeration. There was no identifiable impact on sward quality.

Keywords: soil compaction, sward lifting, slit aeration

Introduction

Sustainable livestock production systems are increasingly reliant on the efficient production and utilisation of 'home-grown' forages. Although an estimated 42 million Mg of forage dry matter are consumed by ruminants in the UK per annum (Wilkinson, 2011), an estimated 70% of grassland soils in England and Wales are exhibiting signs of surface soil compaction (Newell-Price *et al.*, 2013). Research has indicated that soil compaction in grassland can reduce water infiltration, restrict working days, increase nitrous oxide losses and reduce sward productivity (Hargreaves *et al.*, 2013). In addition, Hargreaves *et al.* (2013) observed reductions in first-cut dry matter yield of 14 and 22% from grassland soils compacted by animals and tractors, respectively. Little is known about the effectiveness of soil-loosening treatments on alleviating compaction in grassland soils. Although improvements have been observed in water infiltration rates and soil structure (Bhogal *et al.*, 2011) limited information is available about the impacts on sward productivity. To support on-going research trials examining the effectiveness of sward lifting and slit aeration on grassland soils, two demonstration sites were set up to evaluate the effectiveness of soil-loosening techniques on grass growth, sward quality and soil structure.

Materials and methods

Two 5-ha lowland grassland sites were identified on commercial farms in northern UK. Site A is a three-year-old perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) ley and is located on a sandy-clay loam soil. Site B is a five-year-old perennial ryegrass, located on clay loam soil. Both sites receive c. 250 kg N ha^{-1} fertiliser per annum and are rotationally grazed by lactating dairy cows from March to October. Annual precipitation for site A and site B is 800 mm and 710 mm, respectively. Both sites exhibited signs of severe topsoil compaction at 10-30 cm depth (Figure 1).

Figure 1. Pre-loosening soil at site A and site B.

Site A was subdivided into four 1.25-ha plots, each of which received one of four treatments: (1) no aeration; (2) sward-lifting aeration; (3) slit aeration; and (4) sward-lifting + spike aeration. Sward lifting was undertaken in October 2012 and spike aeration was undertaken in February 2013. In Autumn 2013 the trial was repeated on an adjoining 5-ha plot of similar soil type and under the same management as previously. Site B was subdivided into three 1.6 ha plots and the following three treatments assigned to one plot: (1) no aeration; (2) sward-lifting aeration; and (3) slit aeration. Sward-lifting and slit aeration were completed in December 2013 and March 2014, respectively. Grass dry matter yield and offtake were measured at each site at each grazing event using a rising plate meter (Jenquip, New Zealand). Grass samples were also analysed for dry matter, crude protein and metabolisable energy.

Results and discussion

Throughout 2013 and 2014, the slit-aeration and sward-lifting treatments at site A increased grass growth by 3.8 and 13.0%, respectively, compared to an non-aerated control (Table 1). In-field assessment showed an improvement in soil structure under both treatments compared to the control. The combined sward-lifting and spike-aeration treatment also increased grass growth by 15.1% compared to the non-aerated control. Grass offtake throughout the season was 2.8, 11.0 and 12.1% higher from the slit aeration, sward-lifting and slit + sward-lifting treatments, respectively, compared to the non-aerated control. In both years, increased grass offtake was evident from the first grazing event following aeration.

In contrast, at Site B slit aeration and sward-lifting aeration reduced grass yield at the first grazing event by 8.2 and 6.4%, respectively, and grass offtake by 25.3 and 13.8%, respectively (Table 2). This reduction is most likely due to wetter soil conditions at the time of loosening, coupled with a heavier soil at site B compared to site A. Significant destruction of grass roots was also evident at site B and a narrower time-window between aeration and the first grazing event may have contributed to this reduction in grass yield.

Table 1. The effect of different soil loosening techniques on grass growth, grass offtake and utilisation at site A.[1]

		No aeration	Slit aeration	Sward lifting	Slit aeration + sward lifting
2013	Growth (kg DM ha^{-1})	9,790	10,209	11,146	11,470
	Offtake (kg DM ha^{-1})	6,722	6,890	7,323	7,422
	Utilisation (%)	68.7	67.5	65.7	64.7
2014	Growth (kg DM ha^{-1})	12,474	12,878	13,980	14,106
	Offtake (kg DM ha^{-1})	8,760	9,032	9,911	9,972
	Utilisation (%)	70.2	70.1	70.9	70.7

[1] DM = dry matter.

Table 2. The impact of soil loosening techniques on grass growth, grass offtake and grass quality at site B.[1]

		No aeration	Slit aeration	Sward lifting
Grazing 1	Grass growth (kg DM ha^{-1})	2,670	2,450	2,500
	Grass offtake (kg DM ha^{-1})	870	650	750
Grazing 3	Grass growth (kg DM ha^{-1})	2,815	2,840	2,840
	Grass offtake (kg DM ha^{-1})	1,240	1,246	1,232
DM content (g kg^{-1})		193	184	178
Metabolisable energy (MJ kg DM^{-1})		11.8	11.8	11.7
Crude protein (g kg^{-1} DM)		198	220	221

[1] DM = dry matter.

By the third grazing event however, grass growth on the loosened treatments was comparable to that on the non-aerated control (2,840 vs 2,815 kg DM ha^{-1}; Table 2). There was no clear difference between grass growth on the aerated and non-aerated treatments over the whole season.

There were no apparent differences in grass dry matter or metabolisable energy content between the different aeration methods at either site. However, a small increase in grass crude protein content from the loosened treatments relative to the non-aerated area at site B was evident (Table 2).

Conclusions

Results from demonstration-farm trials suggest that the use of mechanical soil loosening on compacted grassland soils can result in grass yield improvements on sandy loam soils; however, on heavier soils the effectiveness of these techniques will depend on soil moisture levels at the time of loosening.

Acknowledgements

This project was funded through the DairyCo Grasslands, Forage and Soils Research Partnership, led by SRUC, and completed in conjunction with the British Grassland Society. The authors gratefully acknowledge the contribution of the host farmers to this project.

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